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(71) Applicant: 000191962
Morimura Chemicals, Ltd.
Morimura Bldg., 1-3-1 Toranomon
Minato-ku, Tokyo

(72) Inventor: Takehiko OGUCHI
c/o Morimura Chemicals, Ltd.
Morimura Bldg., 1-3-1 Toranomon
Minato-ku, Tokyo

(72) Inventor: Keiki SUGINAMI
c/o Morimura Chemicals, Ltd.
Morimura Bldg., 1-3-1 Toranomon
Minato-ku, Tokyo

(74) Agent: 100077849
Saichi SUYAMA

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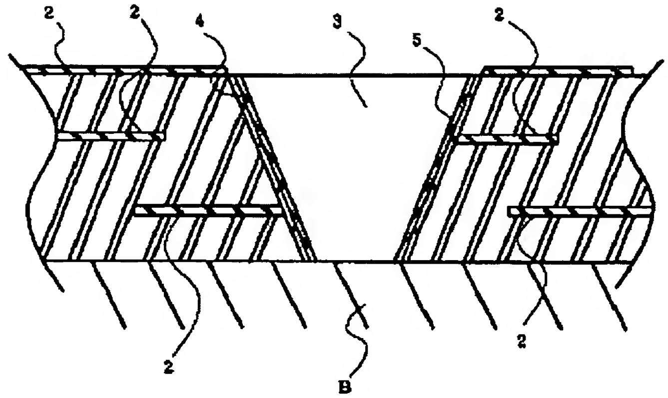
(54) [Title of the Invention] Method for Forming Wiring Patterns, Method for Manufacturing Circuit Boards, and Method for Manufacturing Translucent Objects Provided With A Light-blocking Pattern

(57) [Summary]
[Object] To provide a method for forming a wiring pattern that enables fine patterns to be formed directly onto substrates or the like; a method for manufacturing circuit boards; and a method for manufacturing a translucent object provided with a light-blocking pattern.
[Means of Achievement]An inkjet device is used to draw a circuit pattern on a substrate by means of a metallic particle ink, which is formed by dispersing fine metallic particles having a mean particle diameter of 100 nm or less in water or in an organic solvent; and the substrate is subsequently treated with heat or light rays to decompose and disperse any polymer or surfactant contained in the aforementioned circuit pattern and to obtain a conductor pattern of a desired film thickness. The pattern is directly drawn using the inkjet device, which enables equipment and production costs to be kept low.



[Claims]

[Claim 1] A method for forming a wiring pattern, characterized in that an inkjet device is used to draw a circuit pattern on a substrate by means of a metallic particle ink, which is formed by dispersing fine metallic particles having a mean particle diameter of 100 nm or less in water or in an organic solvent; and the substrate is subsequently treated with heat or light rays to decompose and disperse any polymer or surfactant contained in said circuit pattern, and to obtain a conductor pattern of a desired film thickness.

[Claim 2] A method for forming a wiring pattern, characterized in that an inkjet device is used to draw a circuit pattern on a substrate by means of a metallic particle ink, which is formed by dispersing fine metallic particles having a mean particle diameter of 100 nm or less in water or in an organic solvent; the substrate is subsequently drawn with heat or light rays to decompose and disperse any of said polymer or surfactant contained in said circuit pattern, and to form a conductor pattern of less than a desired film thickness; and a conductive metal is thereafter electroplated on said thin conductor pattern as a plating core to obtain a conductor pattern of the desired film thickness.

[Claim 3] The method for forming a wiring pattern according to Claim 1, characterized in that said fine metallic particles comprise one or more elements selected from among Au, Pt, Ag, Cu, Ni, Cr, Rh, Pd, Zn, Co, Mo, Ru, W, Os, Ir, Fe, Mn, Ge, Sn, Ga and In.

[Claim 4] The method for forming a wiring pattern according to any of Claims 1 to 3, characterized in that said fine metallic particles are coated with a polymer or a surfactant.

[Claim 5] The method for forming a wiring pattern according to any of Claims 1 to 3, characterized in that said fine metallic particles are coated with a block copolymer of a polyester, polyacrylonitrile, polyacrylic acid ester, or polyurethane and an alkanolamine.

[Claim 6] A method for manufacturing a circuit board, characterized in that a wiring pattern is formed on an insulating substrate, using any of the methods described in Claims 1 to 4.

[Claim 7] A method for manufacturing a translucent object provided with a light-blocking pattern, characterized in that a light-blocking pattern is drawn on a transparent substrate, using a paste obtained by dispersing fine metallic particles of an average particular diameter of 100 nm or less in a polymer solution.

[Detailed Description of the Invention]

[0001]

[Technological Field of the Invention] The present invention relates to a method for forming a wiring pattern, a method for manufacturing a circuit board, and a method for manufacturing a translucent body provided with a light-blocking pattern; and in particular relates to a method for manufacturing a translucent body provided with a light-blocking pattern, a method for manufacturing a circuit board, and a method for forming a wiring pattern in which an inkjet head is employed to draw a circuit pattern directly on a substrate, using a metallic paste.

[0002]

[Prior Art] The following are examples of methods used in the past to manufacture circuit boards.

(1) Forming a copper wiring pattern by covering a copper-clad laminated plate with a resist, exposing the circuit pattern to light using photolithography, dissolving away the part of the resist not exposed to the light, and etching the removed portion of the resist.

(2) Forming a conductive pattern by screen-printing a conductive paste on a ceramic substrate in a desired circuit pattern, subjecting the pattern to a heat treatment in a non-oxidizing atmosphere, and sintering the fine metallic particles in the conductive paste.

(3) Forming a copper wiring pattern by vapor-depositing a conductive metal on an insulating substrate to form a thin film conductive layer, covering the conductive layer with a resist, exposing the circuit pattern to light using photolithography, dissolving away the part of the resist not exposed to the light, and etching the removed portion of the resist.

[0003] However, method (1), which employs a copper-clad laminated plate, is not indicated for forming fine patterns, although it is suitable for forming wide wiring patterns; moreover, environmental concerns arise due to the need for effluent treatment, since the method requires

the resists to be dissolved and the copper foils etched. A further problem is presented by the increased equipment and production costs required by the numerous steps involved.

[0004] Method (2), which employs screen-printing, is problematic in that limits are placed on the strength of the screen when a finer mesh is used; accordingly, this method is not indicated for forming fine patterns.

[0005] Method (3), which involves etching a vapor-deposited thin film, raises concerns related to the environment due to the need for effluent treatment, since the method requires the thin film conductive layers to be etched. A further problem is presented by the increased equipment and production costs required by the numerous steps involved.

[0006] On the other hand, photocopiers are used to imprint patterns in the form of characters, images, and the like on transparent films used as projection sheets for overhead projectors (OHP) and other image-projecting devices. However, the light-blocking effect of the photocopier toner, which comprises a particulate obtained by compounding carbon black with a synthetic resin, is inadequate, which causes problems related to insufficient contrast in the projected images.

[0007]

[Problems that the Invention Is Intended to Solve] As has been described in the foregoing, conventionally known methods for manufacturing circuit boards have involved copper-clad laminated plates, screen printing, etching of vapor-deposited thin films, and other techniques. However, methods that employ copper-clad laminated plates or screen printing have had problems related to their inability to form fine patterns, their need for effluent treatments, and their increased equipment and production costs, while methods that involve etching vapor-deposited thin films require effluent treatments, and have increased equipment and production costs.

[0008] Other problems are presented in projection sheets used in conventional OHP or other image-projection devices, since the inadequate light-blocking effect will cause the contrast of the projected images to be insufficient.

[0009] The present invention was perfected in an effort to resolve the aforementioned problems in the prior art, and an object thereof is to provide a method for forming wiring patterns, a method for manufacturing circuit boards, and a method for manufacturing a translucent object provided with a light-blocking pattern whereby the resulting projected images are endowed with

an exceptional light-blocking effect and satisfactory contrast; [in all of these methods] the formation of fine patterns should be simple, effluent treatments unnecessary, the production process straightforward, and equipment and production costs minimal.

[0010]

[Means Used to Solve the Above-Mentioned Problems] The present invention is characterized in that an inkjet device is used to draw a circuit pattern on a substrate by means of a metallic particle ink, which is formed by dispersing fine metallic particles having a mean particle diameter of 100 nm or less in water or in an organic solvent; and the substrate is subsequently treated with heat or light rays to decompose and disperse any polymer or surfactant contained in the aforementioned circuit pattern, and to obtain a conductor pattern of a desired film thickness.

[0011] In the present invention, any desired substrate may be used to form the conductive pattern, depending on the application.

[0012] When a circuit board is to be manufactured, there are no particular limitations as to the substrate used, provided that the material is able to withstand the heat treatment described hereinbelow.

[0013] In other words, examples of substrates* that can be used in the present invention include polyimide films, polyamide-imide films, polyamide films, polyester films, glass-epoxy substrates, paper-phenol substrates, silicon substrates, ceramic substrates, glass substrates, and the like.

[0014] When films or substrates comprising an organic material are used as the substrate, it is appropriate for the polymer with the fine metallic particle ink to be, e.g., a urethane-based polymer that will decompose and disperse at a temperature below the softening point of the material.

[0015] Substrates that are especially suitable when manufacturing circuit boards are polyimide films, polyamide-imide films, glass-epoxy substrates, paper-phenol substrates, ceramic substrates, glass substrates, and the like, which have exceptional heat resistance and electrical insulation properties.

* [Translator's note: the Japanese word here actually means "gas"; however, the context of the description, along with the fact that the word for "substrate" is a homonym for "gas" in Japanese, suggests that "substrate" was the intended term here.]

[0016] Colorless, highly transparent polyester films, glass substrates, or the like are suitable when manufacturing translucent objects provided with light-blocking patterns, as used in OHPs and in other image-projecting devices.

[0017] Examples of the fine metallic particles used in the present invention include Au, Pt, Ag, Cu, Ni, Cr, Rh, Pd, Zn, Co, Mo, Ru, W, Os, Ir, Fe, Mn, Ge, Sn, Ga, In, and the like. However, fine particles of metals such as Au, Ag, and Cu are preferred since they have low electrical resistance and enable corrosion-resistant circuit patterns to be formed.

[0018] In the present invention, the polymer or surfactant used in the fine metallic particle ink is used in the form of a protective colloid for the fine metallic particles; especially preferable are block copolymers of alkanolamines with polyesters, polyacrylonitriles, and polyurethanes.

[0019] The fine metallic particle ink of the present invention comprises water- and oil-base inks.

[0020] Aqueous inks obtained by dispersing the fine metallic particles in a dispersion medium principally comprising water can be prepared, for example, according to the method described below.

[0021] In other words, a water-soluble polymer is dissolved in a metal ion source aqueous solution of gold chloride, silver nitrate, or the like; and then dimethylaminoethanol or another alkanolamine is added thereinto while the solution is stirred. The metal ions are reduced for a period of over several tens of seconds to several minutes, and fine metallic particles having an average particle diameter* of 100 nm or less are precipitated out. Once filtration or another method is used to remove the excess chlorine or nitric acid ions, the solution is concentrated and dried, resulting in high-density ink with fine metallic particles. The fine metallic particle ink can be stably dissolved in and mixed with water, an alcohol-based solvent, tetraethoxysilane, triethoxysilane, or another sol-gel process binder.

[0022] Oil-base inks obtained by dispersing the fine metallic particles in a dispersion medium principally composed of oil can be prepared, for example, according to the method below.

[0023] In other words, an oil-soluble polymer is dissolved in a water-miscible organic solvent such as acetone, and this solution is mixed with an aqueous solution that serves as a metal ion source. The mixture will not be a uniform system, but if an alkanolamine is added thereinto as

* [Translator's note: the Japanese word here actually means "system"; however, the context of the description, along with the fact that the word for "diameter" is a homonym for "system" in Japanese, suggests that "diameter" was the intended term here.]

the mixture is stirred, the fine metallic particles will precipitate out on the oil phase side, having been dispersed in the polymer. Spinning, concentrating, and drying the resulting mixture will yield fine metallic particle ink that has the same density as water-base ink. This fine metallic particle ink can be stably dissolved in and mixed with solvents such as aromatic-, ketone-, and ester-based solvents, as well as with polyesters, epoxy resins, acrylic resins, polyurethane resins, and the like.

[0024] The concentration of the fine metallic particles in the fine metallic particle ink dispersion medium can be increased to a maximum of 80 wt%; however, the ink can be suitably diluted for use according to the application.

[0025] It is normally appropriate for the content of fine metallic particles in the ink to be 2 to 50 wt%, for the surfactant and resin content to be 0.3 to 30 wt%, and for the viscosity to be 3 to 30 centipoise.

[0026] The inkjet device used in the present invention may be a thermal or piezo type. In the case of the former, however, the fine metallic particle ink can be sprayed using the bumping phenomenon in the dispersion medium, so water-base inks are more appropriate for use as the fine metallic particle ink than are oil-base inks.

[0027] The resolution of well-known inkjet devices has reached 2,000 dpi at present; therefore, according to the present invention, patterns having a 6-μm wire width can be formed.

[0028] The method in which a circuit board is formed using a circuit pattern as the conductive pattern in accordance with the present invention shall be described hereunder.

[0029] First, a circuit pattern is formed to a specified thickness on a regular insulating substrate that has been selected according to a given application, using an inkjet device.

[0030] Next, the circuit board is dried by being heated, e.g., for 3 min in an oven heated to 100°C, and is then left to stand for 15 to 30 min in an oven heated to 150 to 300°C to allow the polymer to be decomposed and dispersed and the fine metallic particles sintered, resulting in a conductive pattern.

[0031] By means of the procedure described in the foregoing, the fine metallic particles that constitute the pattern are bonded to each other, converted to a conductive cover film, and fashioned into a conductive circuit.

[0032] The conductive circuit obtained in the aforementioned procedure can be used according to need as a plating core in a regular electroplating process to form a thick-film conductive

circuit pattern. The specific resistance of the resulting conductive pattern will be 10^{-5} to 10^{-6} Ωcm, thereby enabling it to be adequately used as a circuit board.

[0033] It is also possible to eliminate the aforementioned sintering step when forming a light-blocking pattern. The circuit pattern formed by the present invention has exceptional light-blocking properties and may be used to obtain sheets or masks for OHP applications that have exceptional contrast.

[0034]

[Working Examples] The present invention shall be described hereinbelow according to working examples.

[0035] Working Example 1

A fine particle ink that contained 20 wt% Ag (isopropyl alcohol dispersion containing 5 wt% protective colloid resin; average Ag particle diameter: 10 nm) was dissolved in propylene glycol monomethyl acetate until the solid fraction concentration had reached 15 wt%, and a piezo inkjet device was used to draw a circuit pattern with a wire width of 20 μm and a film thickness of 3 μm on a polyimide film, after which the film was dried for 15 min at 150°C.

[0036] The resulting article was then baked for 40 min at 200°C to form a conductive pattern. The resistance of the resulting conductive pattern was 2×10^{-5} Ωcm, which was recognized as being appropriate for use as a circuit board.

[0037] Working Example 2

Using an ink containing Au particles instead of the Ag fine particle ink (aqueous dispersion containing 10 wt% protective colloid resin and 30 wt% Au particles; average Au particle diameter: 100 nm), a piezo inkjet device was employed in the same manner to form a conductive circuit pattern with a wire width of 50 μm and a film thickness of 1 μm on a glass substrate. The same drying and baking procedures were carried out, which resulted in a wiring pattern that had a wiring circuit electrical resistance of 3×10^{-4} Ωcm.

[0038] Working Example 3

A water-based ink that contained 5 wt% of Ag fine particles with an average particle diameter of 20 nm (and 1.5 wt% protective colloid), and also contained 15 wt% Pd of fine particles with an average particle diameter of 50 nm (and 3 wt% of protective colloid), was used to form a circuit pattern on a polyimide film, with a wire width of 10 μm and a film thickness of 0.5 μm, using a thermal inkjet device; and the resulting article was then dried for 15 min at 100°C. The pattern thus obtained was irradiated with UV rays to decompose and disperse the protective colloid resin, and then immersed in a copper electroless plating bath to form a wiring pattern with a 5 μm-thick copper film. The wiring pattern thus formed had a wiring circuit electrical resistance of 3×10^{-5} Ωcm.

[0039] Working Example 4

In this example, the present invention was used in the through-holes of a multilayered wiring substrate.

[0040] As is shown in Fig. 1, several layers of a circuit pattern 2 that had a wire width of 10 μm and a film thickness of 0.5 μm were formed on a polyimide insulating layer 1, using the water-based ink and method employed in Working Example 3. Subsequently, vias 3 in the form of inverted cones were formed so that the connecting portions between each of the circuit pattern 2 layers were exposed, and a thermal inkjet device was used to form a 0.5 μm-thick coating film 4 in these vias, using the same water-based ink, whereupon the resulting film was dried for 15 min at 100°C.

[0041] The resulting coating film 4 was irradiated with UV rays to decompose and disperse the protective colloid resin, and subsequently immersed in a copper electroless plating bath, to obtain through-holes 5 comprising a 5 μm-thick copper film.

[0042] Working Example 5

A projection sheet for use in an OHP was prepared by drawing [a pattern] on a transparent polyester film using the ink and method employed in Working Example 2. The projected image produced from this projection sheet was substantially more vivid, and had a higher degree of resolution and contrast, in comparison to projection sheets prepared by common

inkjet inks. Moreover, no degradation in the image was at all evident, even after the sheets had been stored over an extended period of time, under high temperature and humidity.

[0043]

[Merits of the Invention] As has been described in the foregoing, according to the present invention, hitherto unattainable fine conductive patterns can be formed rapidly on substrates or the like, with a very high degree of accuracy. Moreover, circuits and light-projected images can be formed in a completely dry process. The present invention can be used to form conductive circuits without requiring the resist film to be coated, exposed, developed, plated, or otherwise treated, and without requiring effluent treatment, all of which have been necessary in the past. Moreover, the present invention substantially eliminates problems such as effluent treatment, and therefore contributes substantially towards reducing equipment and production costs.

[Brief Description of the Drawings]

[Figure 1] Fig. 1 is a cross-sectional view schematically depicting part of a through-hole in the circuit board of the present invention.

[Key]

1: polyimide insulating layer

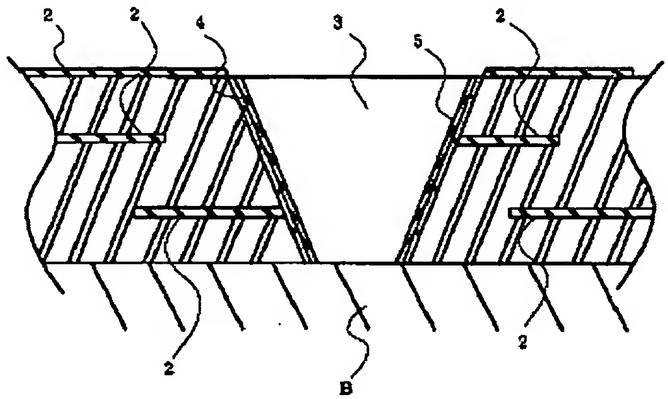
2: circuit pattern

3: vias in the shape of inverted cones

4: coating film

5: through-holes

[Figure 1]



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